PHYS 3702, Intermediate Laboratory—Photons & Nucleons: Spring 2017

Laboratory objectives and prelab questions, January 23, 2017

1 Gamma-ray spectroscopy with HPGe and abundance of uranium isotopes

1.1 Objectives

1. Perform an energy calibration using ^{22}Na, ^{60}Co, and ^{137}Cs. Report errors and energy residuals.
2. Verify that the γ's from the uranium isotope decays can be seen and identified within the spectrum
3. Using the ^{152}Eu source, calculate the relative detector efficiency relevant for the gammas coming from the uranium decays.
4. Determine the ^{235}U/^{238}U ratio, with errors. Compare to the isotope ratio found in "natural" uranium ore; indicate if the isotope ratio sample is natural, enriched, or depleted.

1.2 Prelab questions

1. Look in the Gamma-ray Spectrum Catalog for ^{235}U and ^{238}U. For each isotope pick a gamma ray; using the reported intensities and the lifetimes of the isotopes, write the formula to determine the ratio of the number of nuclei of the two isotopes, where you will keep the peak counts and relative efficiencies as varables.
2. What are typical values of the ^{235}U/^{238}U ratio in naturally occurring uranium ore?

2 Beta-decay and gamma-ray spectroscopy with NaI detectors

2.1 Objectives

1. Perform a rough energy calibration for both detectors to ensure that both the 511 and 1275 keV gammas from ^{22}Na deacy will be identifiable in the spectra
2. Using the software coincidence mode of the data acquisition system, compare the angular correlation for 511-1275 coincidences compared to 511-511 coincidences.
3. Collect data with several thicknesses of material (aluminum or copper) to measure the gamma ray attenuation for both the 511 and 1275 keV gammas.

2.2 Prelab questions

1. What variation of coincidence rate with angle do you expect for 511-1275 coincidences compared to 511-511 coincidences?
2. Find, in literature resources, the attenuation length for 511 and 1275 keV gamma rays in aluminum and in copper. What intensity attenuation would you expect for a 1 cm plate of each material?

3 Alpha-particle spectroscopy with Si

3.1 Objectives

1. Identify all peaks with particular α decays.
2. Perform an energy calibration to verify the association of the peaks
3. Determine the activity of the source, and compare it to the specification of the source.
4. Determine the age of the source, since it was produced. Compare to the age since production.

3.2 Prelab questions

1. Some of the decays in the radium decay chain take place through beta or gamma emission. Why won't the beta and gamma rays produce distinct signals in the detector?
2. The decay energy, or Q-value, represents the energy released in the decay process, and can be calculated from the difference in mass of the parent nucleus and the sum of the masses of the decay products. Are the alpha particle energies identical to the decay energies of the isotopes? Why or why not? If they are not identical, what is the relationship between the decay energy and alpha energy for a particular isotope?

4 X-ray diffraction

4.1 Objectives

1. Take diffraction data on three known samples. Compare the spectra to reference spectra
2. Repeat the data collection for one of the known samples. Compare to the first measuremnt.
3. Take diffraction data on one unknown sample. Use the database to identify the material
4. Use the smallest angle diffraction peak in your unknown spectrum to determine the corresponding distance between the crystal planes.

4.2 Prelab questions

1. What is the relationship between the positions of the first order diffraction peak and the higher order peaks?
2. How can you tell the difference between a higher-order diffraction peak from one spacing and a first-order peak from a different spacing? Do we need to be concerned with the higher-order diffraction peaks?

5 Energy dispersive X-ray spectroscopy (EDXS)

5.1 Objectives

1. Collect imagery and x-ray spectra from at least two locations on four samples.
2. Report on the similarities and differences within each sample.

5.2 Prelab questions

1. What determines the ability of EDXS to identify elemental composition of a material?
2. It is challenging to measure the amount of light elements (such as H, He, Na, Be) in a sample using EDXS. Why?